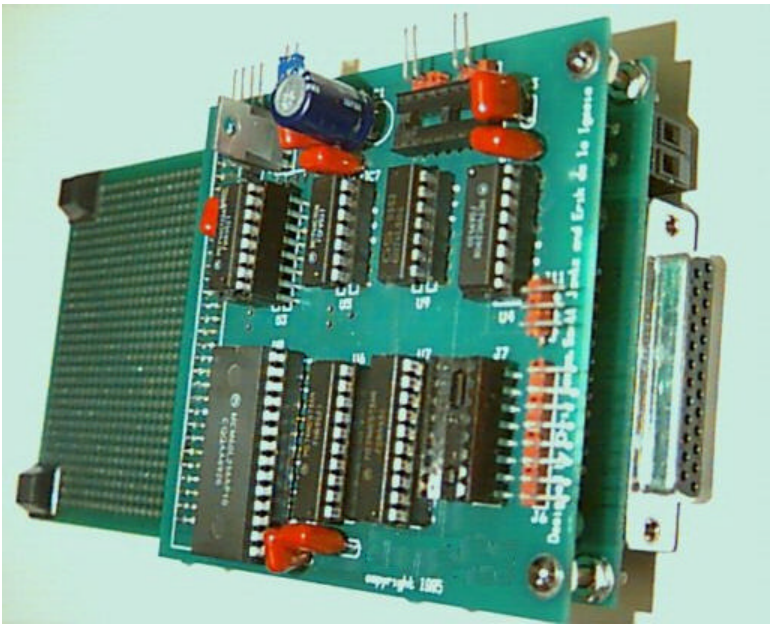
ASSEMBLY MANUAL
MEKATRONIX ME11 EXPANSION BOARD FOR THE MC68HC11 EVBU

BY KEITH L. DOTY



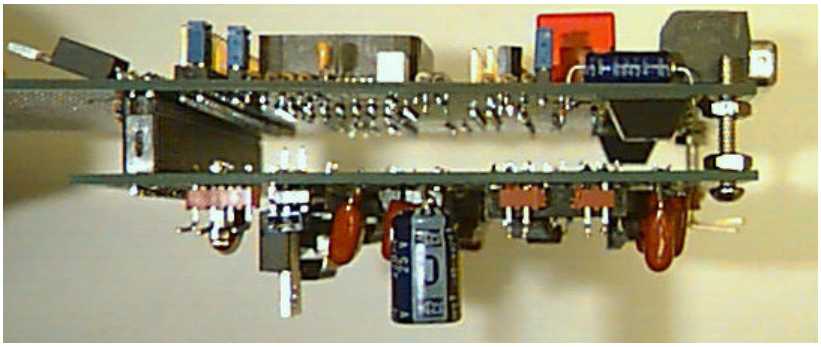


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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 ASSEMBLING MEKATRONIX PRINTED CIRCUIT BOARDS

1.1 Skill Level

Assembling this board requires the ability to solder and modest manual dexterity. If you are inexperienced in soldering or would like a quick review of soldering techniques, refer to *Soldering Note (http://www.mekatronix.com in manuals section)* for soldering tips. If you feel uncomfortable with assembling a printed circuit board you might want to consider purchasing one assembled and tested from the factory .

1.2 Personal Safety

Practice safe assembly techniques. When assembling printed circuit boards, be sure to work in a well ventilated area and wear eye protection. If you have not been instructed in PCB assembly techniques, you should seek assistance from an experienced technician.

1.3 Component Protection

Integrated circuits (IC) and other semiconductor devices are static sensitive. One can easily destroy an IC with static discharge. To protect against static discharge from destroying semiconductor devices, you might want to wear a wrist grounding strap while assembling your board. Axial and radial leaded components, such as resistors and capacitors, while rugged, can be damaged by careless handling. A common failure results when the leads are bent too much and their connection to the component is weakened or broken. Pins on headers and connectors occasionally get bent. To restore the pin to proper function, careful straightening them with needle nose pliers should do the trick, but bending a pin certainly does not improve the pin's performance and can lead to failure.

1.4 Questions and Further Information on the ME11

For technical support email all questions to mek_tech@orlandonet.magicnet.net **.**
For technical information and further description of the ME11, circuit diagrams, IO address mapping, etc., refer to the free manual at http://www.mekatronix.com in the manuals section.

1.5 Equipment Needed to Construct the ME11

The following tools are needed to complete this board. Make sure you have them handy before you start work.

1. Soldering iron
2. 60/40 rosin core 0.032 diameter electronics solder (do not use an acid core solder or acid flux on the board)
3. Small diagonal cutters for cutting wire and headers
4. Needle nose pliers
5. Wire stripers
6. Hot glue gun and hot glue for mechanically securing wires to connectors
7. Masking tape

1.6 Equipment Needed for Testing the ME11

You will need the functionality or equivalent to the following equipment.

1. Multimeter
2. Power supply or 8 pack of AA rechargeable batteries to supply about 7-10 volts (We recommend Energizer rechargeable AA NiCad Batteries)
3. A MEKATRONIX™ C2325 6-wire serial cable.
4. A Personal Computer running DOS or Windows with a 25 pin serial cable connector capability for COM1 or COM2 to connect with the MB2325 board.
5. Motorola PCBUG11 (freeware) or Interactive C (freeware for versions less than 3.1) or ICC11 (purchase from a MEKATRONIX™ distributor).
6. Jumpers and/or switches

2 THE ME11 EXPANSION UNIT FOR THE EVBU

The APPENDIX depicts the organization (Figure 3), layout (Figure 1 and Figure 4), circuit (Figure 5, Figure 6, Figure 7, Figure 8), and I/O addresses mapping table (IO Memory Map of the ME11
Table 3). A brief describes of the circuit can also be found in the APPENDIX.

3 ASSEMBLING THE ME11

Note: *top of board* refers to the side with the white part outlines and text on it.
bottom of board refers to the non-text side of the board.

Figure 1depicts the component placement on the ME11 printed circuit board. The part labels in Table 1 correspond to the part labels in Figure 1. Figure 1 and Table 1, together, illustrate how to place the components for soldering. Figure 2 details the pin-outs on header J3. The entire microprocessor bus is available on J3.

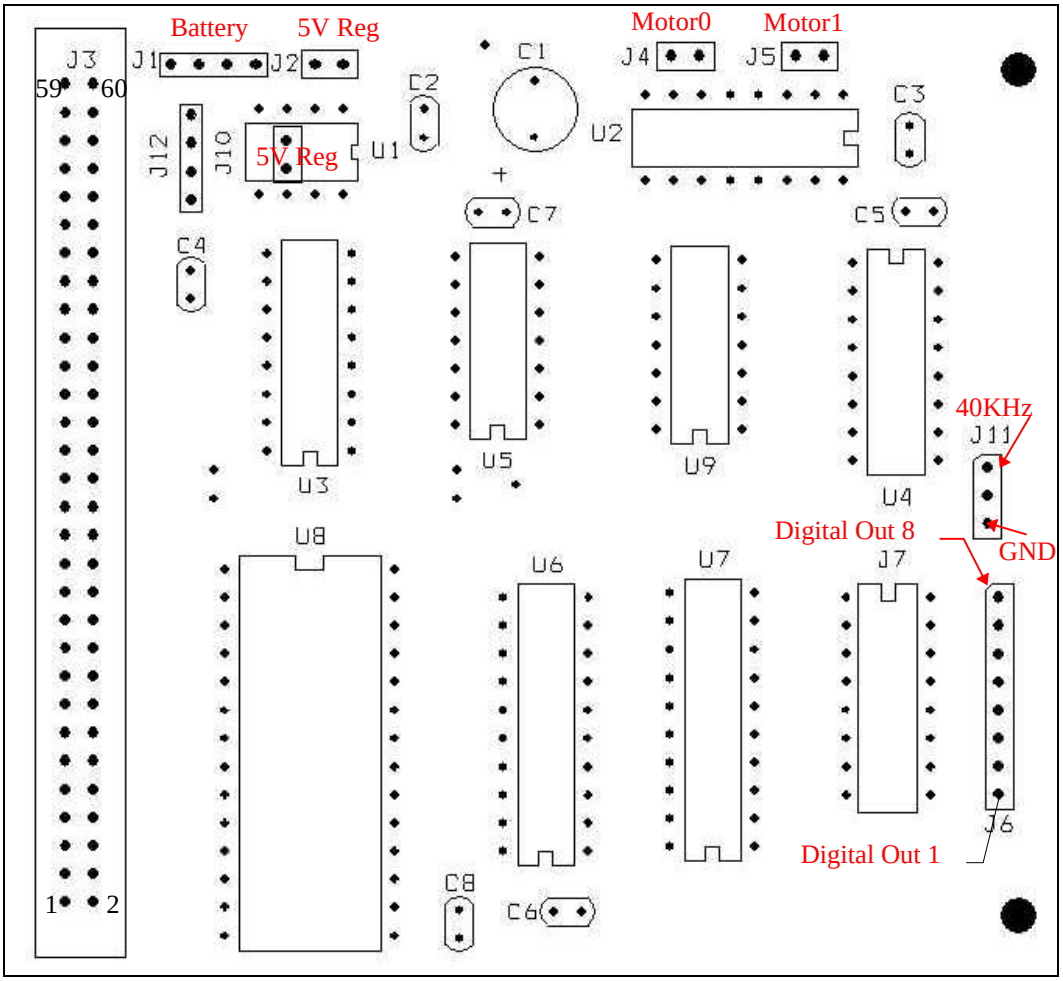


Figure 1 ME11 Board layout.

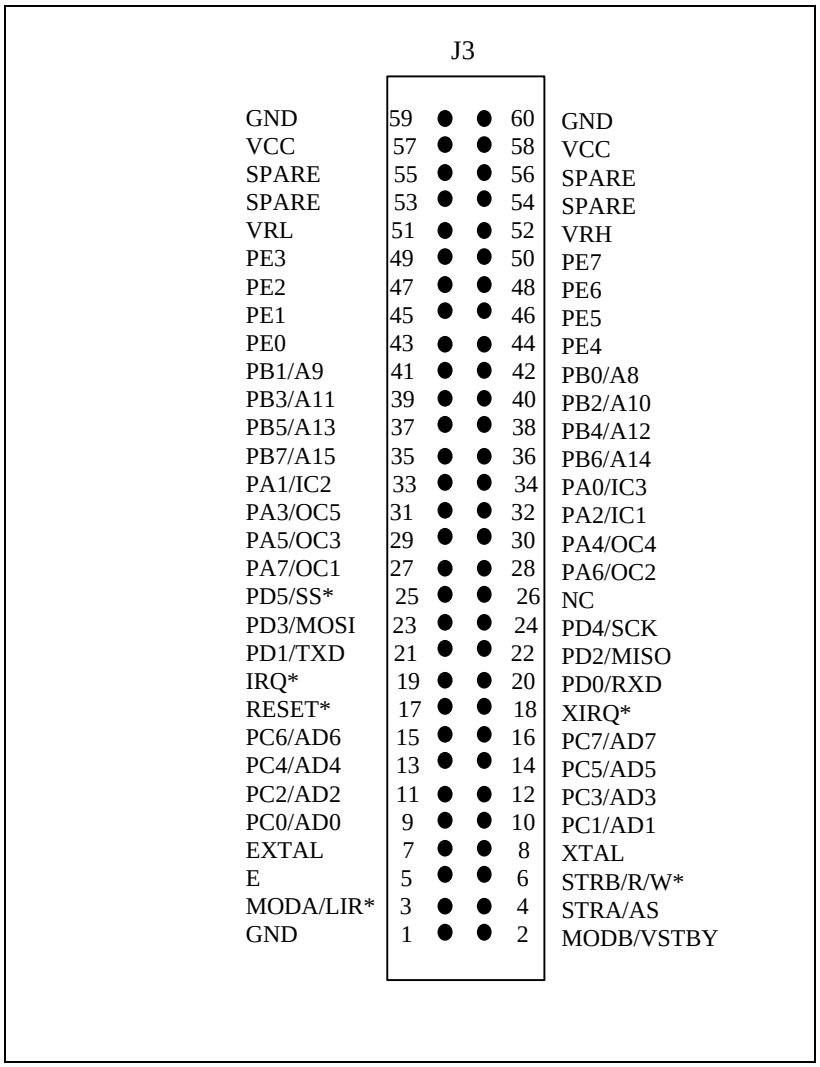


Figure 2 Pin outs for J3 header on the ME11 board.

Table 1 ME11 Parts List

Label	Value	Component Description	Polarized Device
C1	470mf	Electrolytic capacitor (Positive terminal facing C7)	Yes
C2-C8	0.1µf	Bypass Capacitor	No
J1	4 pin Right Angle Male Header	Power connector from battery -no connection if plug reversed	Yes
J10		Footprint for 5 volt regulator	No
J11	3 pin Male Header	Jumper to modulate/not modulate digital output driven by U7 through J7.	No
J12	4 pin Male Header	Two memory mapped digital inputs and two digital outputs	No
J2	2 pin Right Angle Male Header	Jump 5 volt regulated power to Port B and Port C Power Rails	No
J3	60 pin Female Connector	Microprocessor pins plus power, ground.	No
J4	2 pin Right Angle Male Header	Motor connector	No
J5	2 pin Right Angle Male Header	Motor connector	No
J6	8 pin Right Angle Male Header	Digital output Port driven by U7 through J7	No
R1-R8	1KΩ	Resistors connected across J7	No
SJ7	16 pin	Socket for J7	Yes
SU2	16 pin	Socket for U2. Important: Mount each socket to position its notch over the notch printed on the printed circuit board.	Yes
SU3	16 pin	Socket for U3	Yes
SU4	16 pin	Socket for U4	Yes
SU5	14 pin	Socket for U5..	Yes
SU6	20 pin	Socket for U6	Yes
SU7	20 pin	Socket for U7	Yes
SU8	28 pin	Socket for U8	Yes
SU9	14 pin	Socket for U9	Yes
U1	LM2931T	5 volt regulator	Yes
U2	SN754410	Motor controller	Yes
U3	74HC138	3 to 8 Decoder for Memory Mapped IO address decoding 16 pins	Yes
U4	74HC390	Decade counter, generates 40KHz from 2MHz, 16 pins	Yes
U5	74HC10	Three 3-input NAND Gates	Yes
U6	74HC573	Memory low-address-byte latch, 20 pins	Yes
U7	74HC573	8-Bit digital output driver, 20 pins	Yes
U8	SRAM	32Kbyte Memory, 28 pins	Yes
U9	74HC04	Hex Inverter	Yes

Table 2 ME11 Parts Count

Qty	Value	Component Description
1	470µf	Electrolytic capacitor (Positive terminal facing C7)
7	0.1µf	Bypass Capacitor
18 pins	Right Angle Male	8+4+2+2+2 Pin Male Headers
7 pins	Male Header	4+3 Pin Male Headers
1	60 pin Male Header	Male Socket Header
2	14 pin socket	IC socket
4	16 pin socket	IC socket
2	20 pin socket	IC socket
1	28 pin socket	IC socket
8	1KΩ	Resistors connected across J7
1	LM2931T	5 volt regulator
1	SN754410	Motor controller
1	74HC138	3 to 8 Decoder for Memory Mapped IO address decoding 16 pins
1	74HC390	Decade counter, generates 40KHz from 2MHz, 16 pins
1	74HC10	Three 3-input NAND Gates
2	74HC573	8-bit latch
1	SRAM	32Kbyte Memory, 28 pins
1	74HC04	Hex Inverter

3.1 Mounting Components on the ME11 PCB

1. Place small 0.1uf capacitor leads through the pins labeled C2 through C8 on top of board.

2. Solder capacitor leads on bottom of board then clip excess leads off with the diagonal cutters (dikes). Be sure to wear eye protection. Clipped leads can fly in any direction.

Comment on Sockets: *Although quite rare, on occasion sockets have shorts between a pair of pins or a pin may be open circuited. These manufacturing defects can cause serious hardware debugging problems. Most users do not bother checking sockets, because defective ones are so rare. But, the user should be informed of such possibilities.*

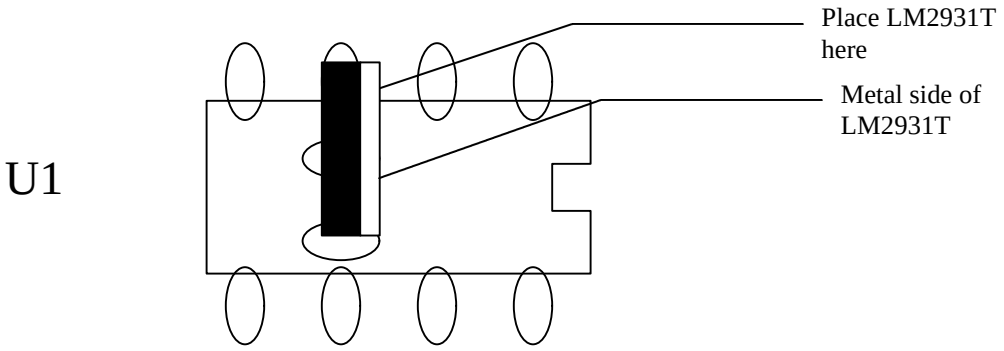
3. Tape in IC sockets with masking tape with the notch on the socket lining up with the notch in the outline on the top of the board. Flip the board and solder the sockets leads, taking care to ensure that the sockets lie snug and flat against the top surface of the board. Solder opposite diagonal pins first in order to clamp the socket securely to the board. Solder the rest of the socket pins as desired.

4. From a right angle male header strip, use the dikes to cut right angle male headers J1(4 pin), J2(2 pin), J4(2 pin), J5(2 pin), J6(8 pin), J11(3 pin) and solder them in the locations specified on top of the board.

***Note**: Occasionally one bends a pin. Use the needle nose pliers to straighten them. **Caution**: Pins cannot withstand too much bending without damage and loss of function.*

5. Use the dikes to cut male straight header J12 (4 pin) from a male header strip and solder in the area marked J12.

6. Insert the LM2931T voltage regulator into the board with the metal back toward C1 and the regulator shifted toward the edge of the board.

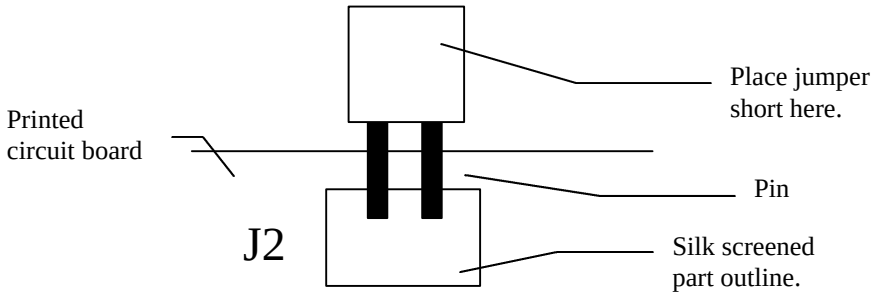


7. Mount and solder C1 into the place marked for it, making sure that the positive side of the cap aligns with the "+" sign (pin closest to C7). Some polarized capacitors may have markings indicating the negative side.

***Caution:** Make sure you understand the markings on the capacitor before soldering it on the board. Improperly soldered electrolytic or tantalum capacitors can rupture with applied voltage.*

8. Place a jumper or switch on J2 of the ME11(refer to the figure below). J2 connects the backup power supply to the rest of the circuit power. Without J2 shorted only the SRAM receives power. This jumper will be used later to put the board in a power-save mode where only the SRAM receives power. The power-save mode preserves programs in memory .

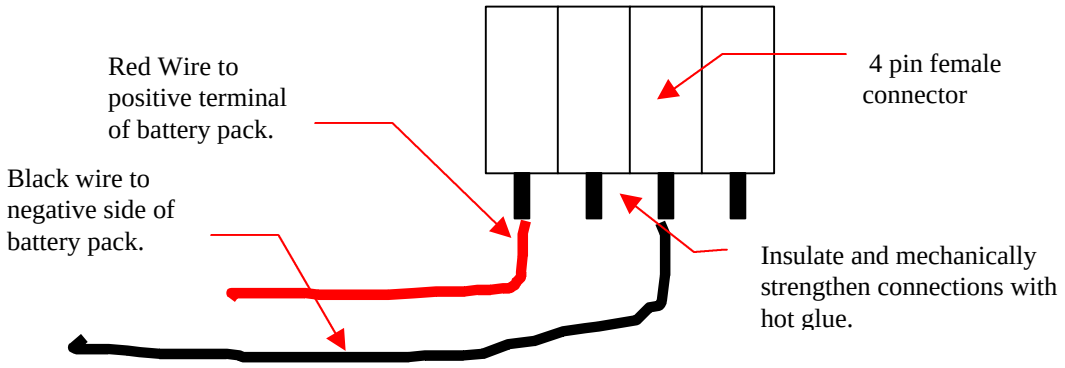
- Make jumpers from female connectors by cutting a two pin section from a single row female header with the dikes. Short the pins together with a lead clipped from a resistor or capacitor. Solder the pins and the lead together.



9. Make a battery pack for the robot using a 8-pack of batteries by connecting a 4 pin female connector (see below) to the wires coming from the battery pack. The positive lead should go to pin 1 and the negative to pin 3. (On most battery packs the red wire is the positive lead.) If you are testing the board with a bench top power supply, make

sure that you assemble a connector like the one below to enable the power supply to power the board. This connector mates with the 4 pin J1 male power header. This plug is polarized. If it is plugged in wrong, nothing happens!

- Using the wire strippers, strip about 1/8 inch of insulation off the ends of the wires you will solder to the female connector shown below. The wire length depends upon the application. For the TALRIK robot, a wire length of 5 to 6 inches will do.
- Tin the bare wire and the female pin.
- Solder the wire and female pin together.
- Insulate the exposed wire on the connector with hot glue.



10. After the ***empty*** battery pack is plugged into the ME11 board, use the multimeter to test for a short between the positive and negative terminals on the battery pack. Some multimeters have a short circuit indicator that will beep if a short is detected. If there is a short circuit between power and ground, check for solder bridges or improper component placement. **Do not continue until all shorts are eliminated**. The multimeter should read an open circuit (infinite resistance) on a correctly assembled board

11. Plug the battery pack into J1 with the positive lead toward J3. If the voltage regulator (LM2931T) gets too hot, quickly unplug the battery pack and test for shorts again. If the voltage regulator (LM2931T) remains cool, use a multimeter to test for 5 volts and ground at the pins indicated in the following table:

IC	Ground At Pin No.	+5VDC at Pin No.
U2	4, 5, 12, 13	16
U3	8	16
U4	8	16
U5	7	14
U6	10	20
U7	10	20
U8	14	28

If your readings do not match the above table make sure you are reading the correct pins (Note: testing from the bottom of the board mirrors the pin positions and makes the measurement process error prone). To be on the safe side, verify that none of the other pins on the sockets have either 5volts or ground on them.

3.2 EVBU Board Modification

If the user plans to use the ME11 with a Motorola 68HC11 EVBU board, the following step must be performed.

12. *On the bottom of the Motorola 68HC11 EVBU board cut the jumper J4.* ***This must be done before joining the two boards in the next step.***

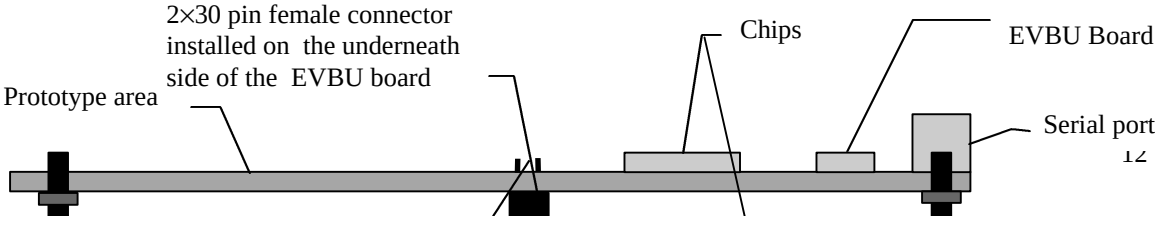
4 JOINING THE ME11 WITH THE EVBU AND TESTING

Note: *The following step is virtually irreversible, i.e., once joined together, the ME11 and the EVBU boards are difficult to separate without risk of damaging one or the other of the boards. The user may wish to connect the boards by ribbon cable and ribbon cable connectors instead. The latter makes mounting a bit more difficult because the ME11 only has two mounting holes.* ***A 2x30 pin female connector (supplied separately from the ME11 kit or assembled version) must be soldered onto the EVBU in order to mate the ME11 with it. See below.***

Be sure to do Step 12 above before proceeding.

13. Procedure for mating the Mekatronix™ ME11 with the 68HC11 EVBU board.

- Select a double row male header with extended pins and the double row female connector.
- Carefully cut the headers at the 61st pin (unless your kit already has 60 pin lengths.)
- Insert the female 60 pin dual row header through the P5 header opening on the EVBU from the underside (refer to figure below).
- While firmly holding the female connector snugly to the EVBU solder one pin at each end.
- Solder all the other pins of the female connector.
- Insert the male header pins into the 60 pin dual row female connector on the underneath side of the EVBU. This insures the connectors align.
- Next, insert the male header solder pins on the ***underside*** of the ME11 board through the J3 header opening (refer to figure below).
- Pass two 1.5inch 4/40 machine screws through the mounting holes of the EVBU. By hand, lightly screw on two hex nuts onto each bolt. These nuts will allow the user to create a flexible standoff between the two boards. With the top nut clamp each bolt to the ME11.The other nut on the bolt will be used to maintain the separation of the boards (refer to the figure below).
- Pass the mounting bolts through the ME11 holes and screw on two more hex nuts, one on each bolt.
- Use the nuts to align and level the ME11 board with respect to the Motorola EVBU board (see figure). When the boards are parallel, secure the nuts with a screwdriver.
- Solder opposite diagonal pins on the male header to the ME11. This locks the male and female components into place on their respective boards. Solder all the other pins on the male header. The two boards are now firmly connected and cannot easily be separated. In fact, we recommend that the two boards never be separated, otherwise damage to the boards or the connectors may ensue.



14. ***Unplug the power pack*** and on the ME11 board insert the SRAM in socket U8, 74HC573 in socket U6, and 74HC10 in socket U5.

15. Establish serial communication between your computer and the EVBU-ME11 system.

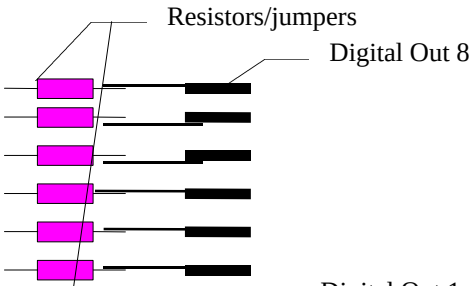
- Attach a serial cable with a 25 pin D-connector to the EVBU serial port and connect the other end to your personal computer COM1 or COM2 port.
- Use shorting jumpers across J3 and J4 on the EVBU to ground MODA and MODB and force the MC68HC11 processor into special bootstrap mode.
- Connect battery plug to J1 on the ME11 board to power up. The ME11 provides regulated power to the EVBU.
- Initialize the board using Interactive C (IC), a C interpreter developed at MIT. IC is assumed to be on your computer running under DOS, although there are MAC and UNIX versions as well (Refer to the sheet titled "Loading Pcode onto the E9 Chip Rev.2" at *http://www.mil.ufl.edu/imdl* .)

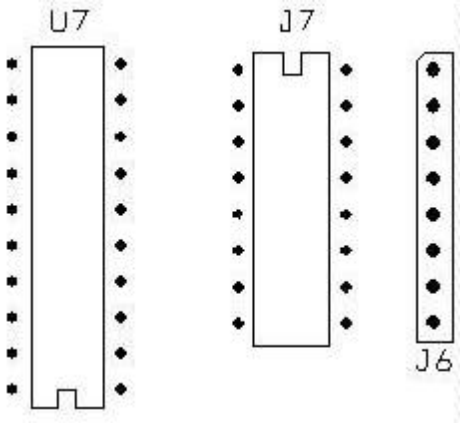
16. Once IC runs on the assembled ME11-EVBU system, ***disconnect*** the batteries and insert the rest of the chips:

U2: SN754410, Motor Driver
U3: 74HC138, 3 to 8 Decoder
U4: 74HC390, Decode Counter
U7: 74HC573, Latch
U9: 74HC04, Inverter

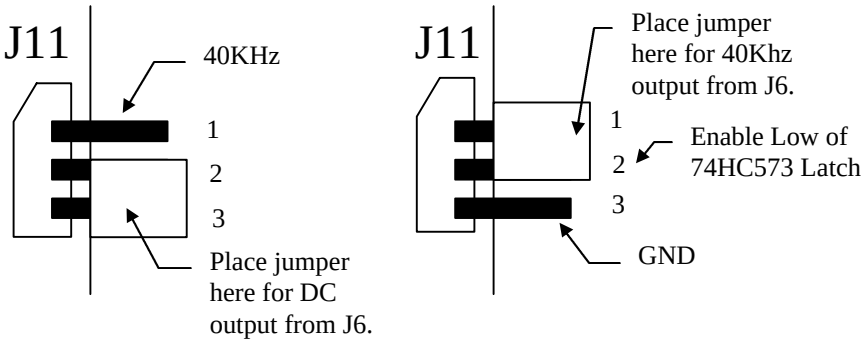
17. Load IC once more and hook up motors to jumpers J4 and J5 on the ME11 board. In IC type "motor(0,100.0);" and "motor(1,100.0);" to test the motor driver. Once you verify that the motor driver works, test the memory mapped output at J6 on the ME1 by doing the following.

- Place resistors R1 to R8 in parallel across the 16 pin J7 socket (see figure below). Push the resistor leads directly into the socket holes. The user can also put other values of resistance across J7, depending upon the application.





- Jumper J11 as follows (looking onto the component side of the ME11 board):



- The MC68HC11 uses Memory-Mapped Input/Output which means that every Input/Output device has an address. In this example, Digital Output Port J6 has address 7000 hexadecimal. Test J7 with "*poke(0x7000,0xff)*". This command will place all ones on the J6 pins, provided a resistor or jumper connects the J6 pin to the 74HC573 (U7) via J7.

18. Your board works! You now have constructed the " memory and sensory" component for a mobile robot, or whatever other application you have in mind!

5 APPENDIX

IO Memory Map of the ME11

Table 3 Memory Map of ME11 IO Enables

Name	Direction	Memory Address (Hex)
Y0	Output	$4000
Y1	Input	$4000
Y2	Output	$5000
Y3	Input	$5000
Y4	Output	$6000
Y5	Input	$6000
Y6	Output	$7000
Y7	Input	$7000

Functional Organization of the ME11

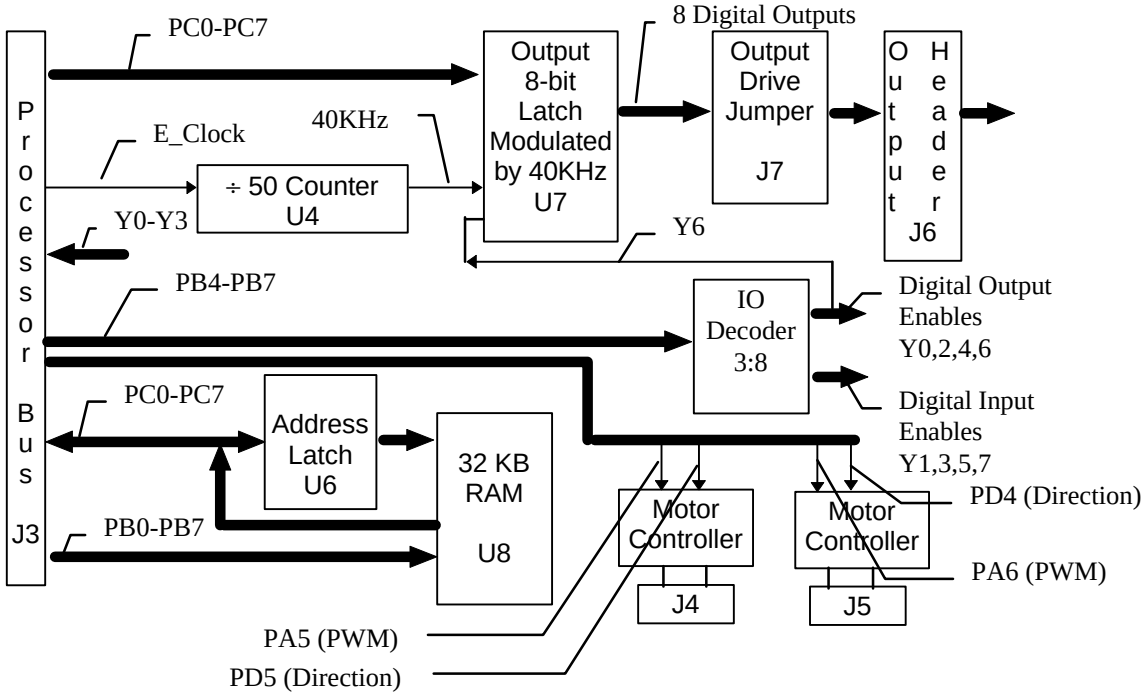


Figure 3 Functional layout of the ME11.

PCB Layout of the ME11

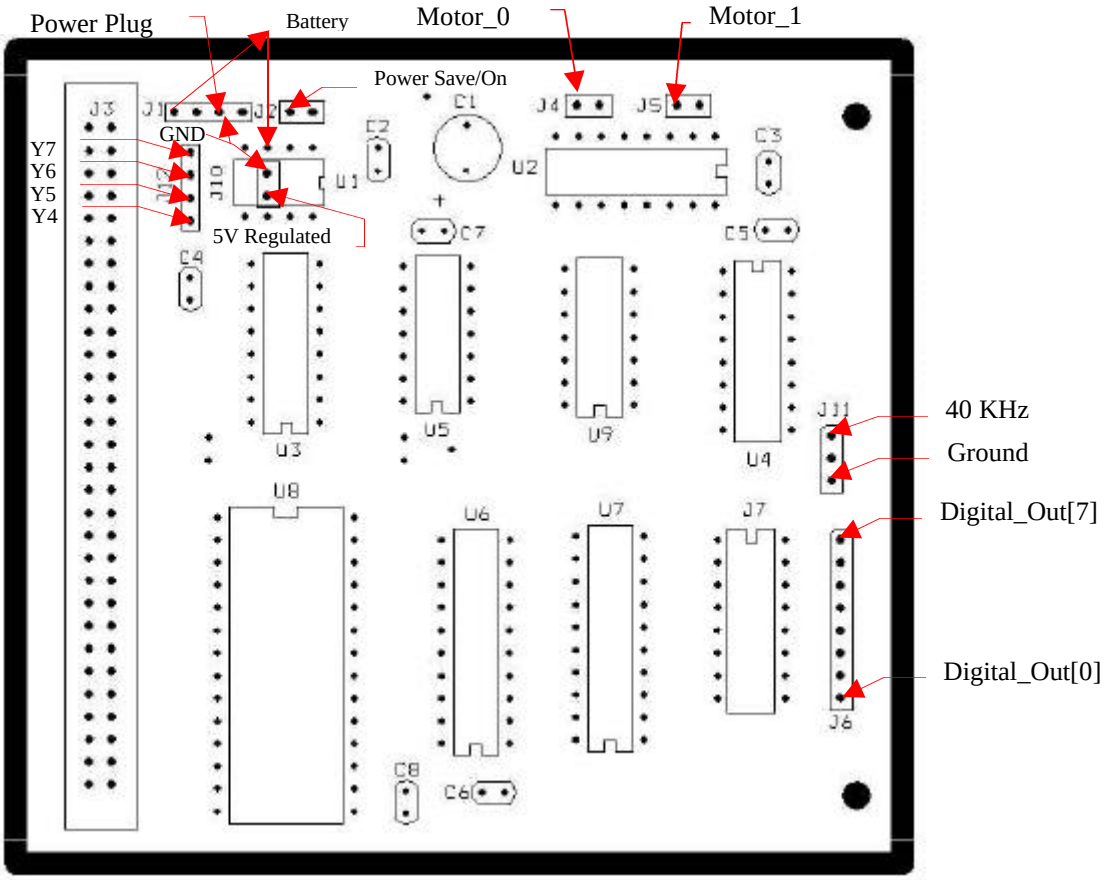


Figure 4 PCB layout of the ME11.

Circuit Schematic of the ME11

Figure 5, Figure 6, Figure 7, and Figure 8 depict the ME11 schematic. The address latch U6 supports the 32KB memory U8 in Figure 5. U4 generates a 40Khz square wave which can modulate the eight outputs of latch U7 via the jumper J11. Alternatively, J11 can ground the output enable of the latch to allow the user to employ the eight outputs of latch U7 as unmodulated, direct digital outputs. The 3:8 decoder U3 permits the user to control four memory-mapped input enables (Y_1, Y_3, Y_5, Y_7) and four memory-mapped output enables (Y_0, Y_2, Y_4, Y_6).

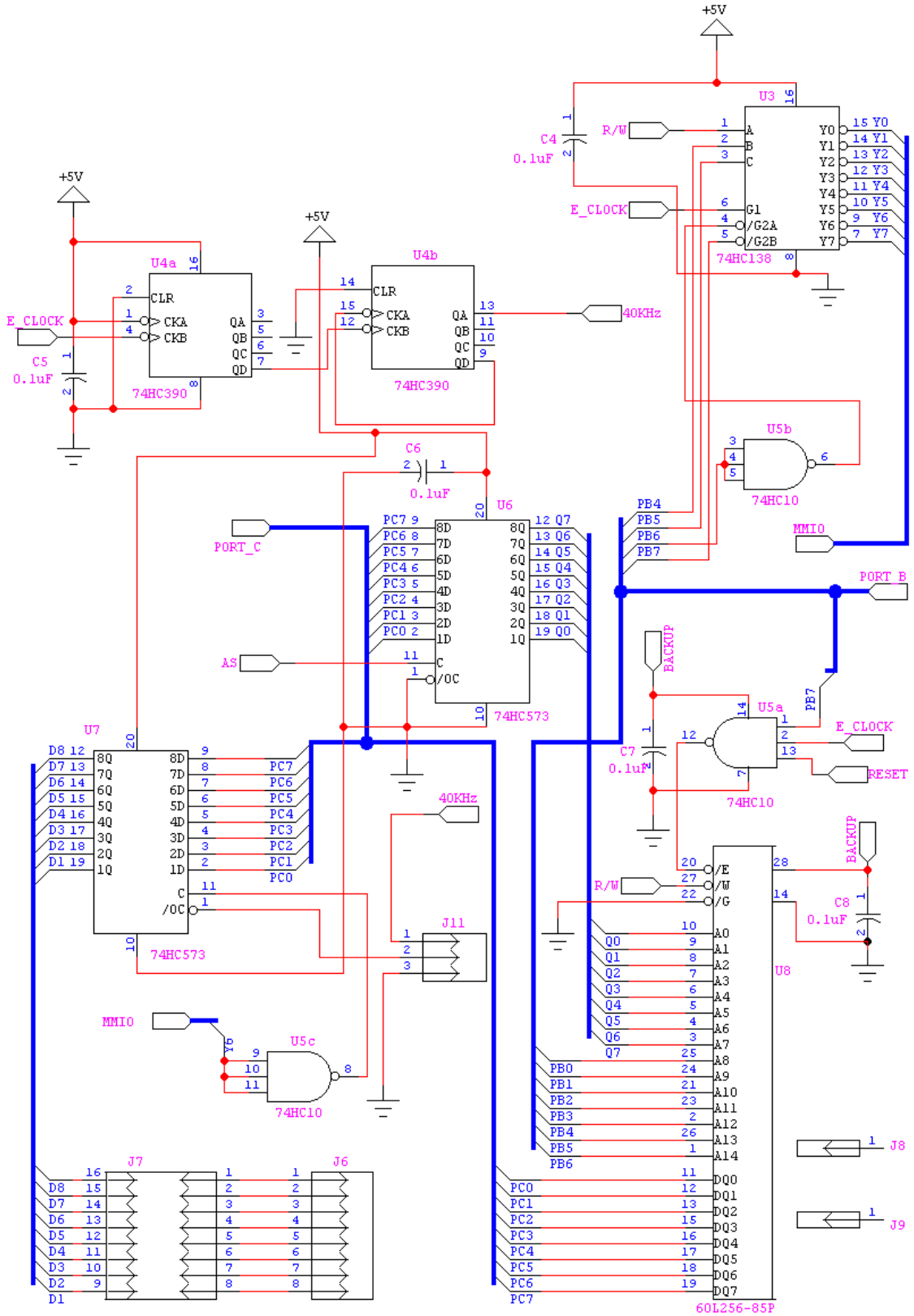
Figure 6 depicts the 60-pin header that connects the ME11 to the underside of the Motorola EVBU board and is pin-for-pin compatible with the EVBU. Spare pins on the header connect to the 40Khz signal, two input enables (Y_1, Y_3) and two output enables (Y_0, Y_2). The other memory mapped IO enables connect to J12.

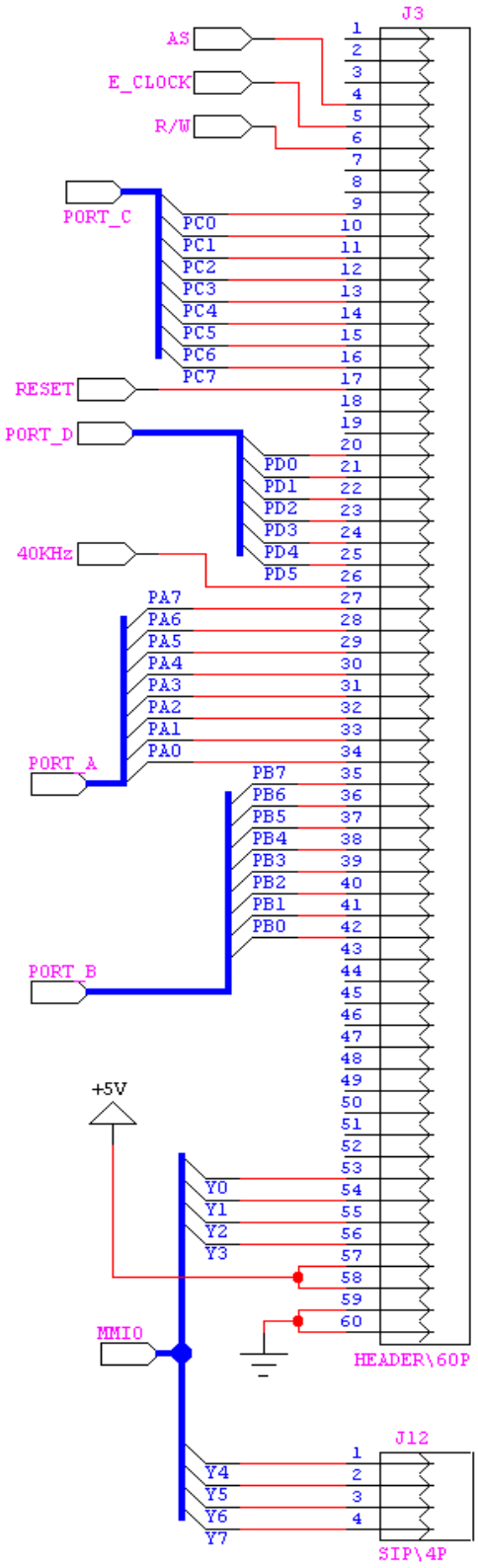
The voltage regulator and associated jumpers in Figure 7 provide several features and options. Connector J1 provides power and ground from an external battery. The low-dropout regulator U1 supplies back up power for the RAM and can power the other components on board through jumper J2. A switch across J2, therefore, allows the user to turn off power to the rest of the board without losing memory. J10 is not a jumper or connector, but only provides extra vias that permit the user to replace U1 with a three pin, 5-volt, standard 7805 compatible voltage regulator.

U2 in Figure 8 controls two DC motors. Port_A generates pulse-width modulated signals that drive the motors while Port_D connections control motor direction. When mounted with a heat sink, U2 can provide up to 1A continuous current to each motor.

Figure 5 ME11 memory, 40Khz generator, IO enables and digital outputs. (Next page)

Figure 6 Processor and IO chip select header.(Two pages hence)


+5V
U3
74HC138
R/W
E_CLOCK
C4
0.1uF
U4a
U4b
74HC390
40KHz
C5
0.1uF
C6
0.1uF
U5b
74HC10
U6
74HC573
PORT_C
AS
MMI0
PORT_B
BACKUP
U5a
C7
0.1uF
RESET
U7
U5c
J11
J7
J6
J8
J9
U8
C8
0.1uF
60L256-85P


J3
AS
E_CLOCK
R/W
PORT_C
PC0
PC1
PC2
PC3
PC4
PC5
PC6
PC7
RESET
PORT_D
PD0
PD1
PD2
PD3
PD4
PD5
40KHz
PA7
PA6
PA5
PA4
PA3
PA2
PA1
PA0
PORT_A
PB7
PB6
PB5
PB4
PB3
PB2
PB1
PB0
PORT_B
+5V
Y0
Y1
Y2
Y3
MMIO
HEADER\60P
J12
Y4
Y5
Y6
Y7
SIP\4P

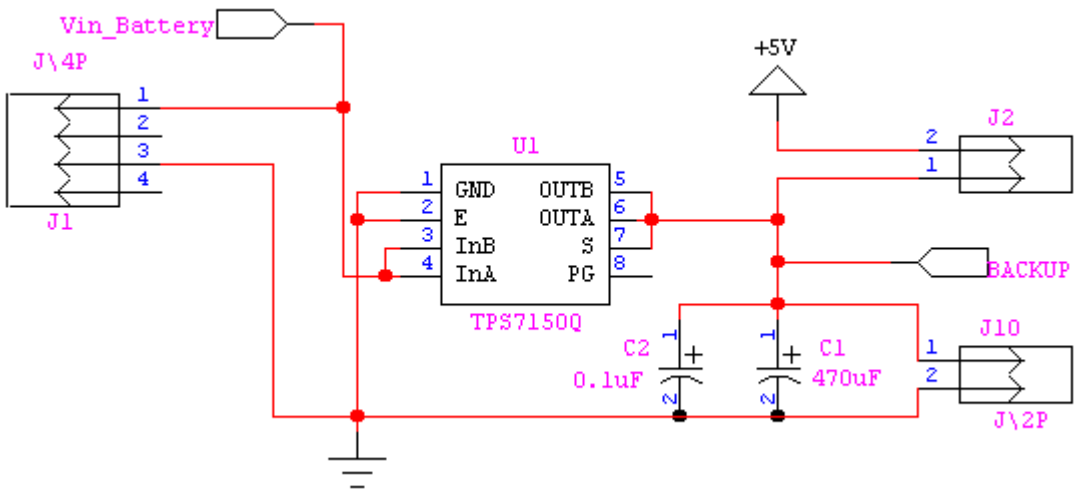


Figure 7 Voltage regulation and power jumpers.

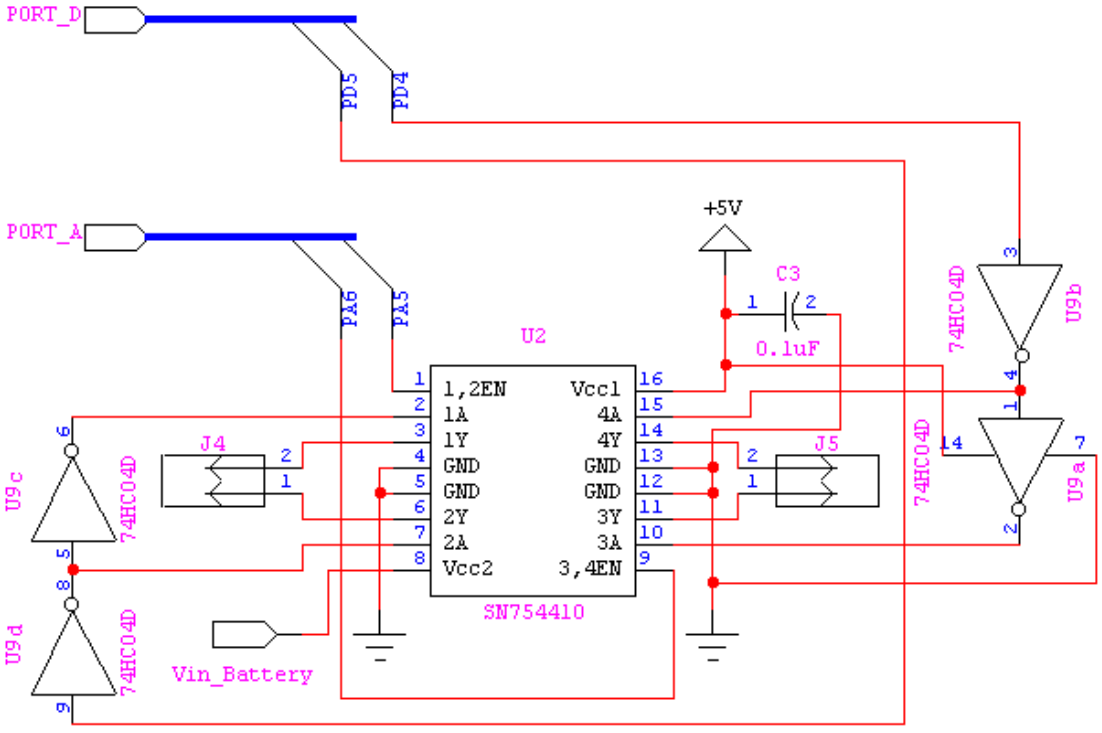


Figure 8 Dual DC-motor control.